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EFFICIENCY EVALUATION AND COMPARISON OF DIFFERENT TURBULATOR SHAPES IN SOLAR WATER HEATING COLLECTOR SYSTEM

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ABSTRACT

Solar flat plate collector is mostly used for the heating purposes like heating of water or any fluid and also used for heating the space or drying purpose. The solar flat plate collector is one of the best methods for the utilization of renewable source of energy. The main component which we use for the fabrication of solar flat plate collector is Absorber tubes (whether it may be aluminium, copper or any other material depending upon the thermal conductivity of material), Glazing, Insulation, wooden box or housing enclosing whole assembly. The absorber tubes used high thermal conductivity materials made of copper material for absorbing the maximum solar radiation. The absorber sheet/plate is also placed inside the wooden box and is coated with black paint and make it black body for the absorption of maximum solar radiation. The glass (thickness 5mm) is also used for reducing the loss of solar radiation from the wooden box/whole assembly. One interesting point here is that we install turbulator inside the absorber tubes for converting the laminar flow to turbulance flow. Here we use the two turbulators, first one is coil-spring turbulator and other one is Twisted tape turbulator. Now vary the length and twist/turn of turbulator and is installed in the absorber tubes for destructing the boundary layer inside the tubes. The objective of the present study is to evaluate the performance of flat plate collector with different geometric absorber configuration. It is expected that with the same collector space higher thermal efficiency or higher water temperature can be obtained. A testing setup is fabricated and performing the experiment taking a different parameter to study the heat enhancement of flat plate collector.

KEYWORDS: Flat Collector, Solar Energy, Renewable Energy & Natural Circulation

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Original Article

INTRODUCTION

Solar energy is one of the most renewable energies available at no cost. Solar radiation falls on the surface of earth and can be used for the benefit of human resources. One of the most popular devices called a solar water heater, which also works by utilization of solar energy. There are many types of equipment which are used for replenishment of solar energy; solar water is one of them. In a single family 20% of electricity is consumed for heating water that is very expensive. In industries, cost of heating water is very high that too is done by burning fossil fuels which lead to a man cause of environmental pollution. Then solar water heater is a best alternate for heating water and producing steam. Although its initial cost is very high, but that gets negotiated with them.

Solar radiation falls on flat plate collector which converts solar energy into heat that can be used for heating water up to 60 to 70 degree. Solar water heater is very effective in developing countries like India as we borrow fossil fuels from gulf countries which prove very costly. In industries huge solar heater can be installed for

producing steam which will be very beneficial for the healthy environment and also decrease the dependency on fossil fuel. Government has to establish more research department for the use of solar energy and make it mandatory for the use of solar water heater in homes as well as industries. In addition to this they have to provide subsidy to villagers so that they can also make use of solar energy.

The solar energy is used for the purpose of heating air and water. In cold climates region, we need heated air for comfort, and in all countries where climate is too cold, hot water is used for washing and other domestic purposes. For example, about 30% in the country of UK's energy consumption, about 20% is used for heating fluids to 'low' temperature (<100*C). Because of this wide range, the manufacturers install solar water heater especially in cold region countries. A large variety of solar water heater is needed for domestic and industrial purposes.

For the purpose of solar energy system, there are two type technique is used Active and Passive technique. If we use the external agent for heating the air, it's called a passive technique and if the fluid is heated only with the help of solar energy it is called Active technique. In any type of solar collection device, the principle which usually followed that we have to expose the black surface of solar collector for absorbing the maximum radiation of solar so to increase the thermal efficiency of flowing fluid. The important point which should be noted that if no optical concentrator is used, the device is then called as Flat-plate collector. The flat plate collector is the most important type of collector because it's simple in design and having no movable parts and it requires a little maintenance. It can be used for a variety of applications in which temperatures ranging from 40 to 100 degree are required.

Turbulator

A turbulator is a device that turns a laminar flow into a turbulent flow. The tabulator produces a hindrance in the flow of water. The turbulator is applied to a variety of application and its used as a derivative of the world turbulance.

Figure 1: Coil-Spring Turbulator

EXPERIMENTAL SETUP

The experimental setup consists of a flat plate collector and the dimension of the setup is 72.96 × 72.96 cm connected with well insulated storage tank having capacity of 10 liter. The cold water from the lower header is evenly distributed in the riser tube and the outlet of the tube is well connected to the hot storage tank. Finally hot water is collected from the outlet of the tube and is collected in the insulated storage tank. The temperature difference in the storage tank accelerates the driving force and the cycle is repeated until the temperature between inlet and outlet of the water is zero. Single transparent glass covers of 5mm thickness transmit the solar energy to the absorber plate. The collector and the pipe are well insulated to minimize the heat losses. Absorber plate and riser tube are made of aluminum. Taps are provided to

measure the inlet and outlet temperature of water, Absorber plate temperature, Riser tube temperature and pressure drop in each riser tube. The wire coil tabulator is inserted in each of the tubes. The length of the larger tube is 65.5cm and the length of the smaller tube is 52cm. These tubes are connected with U-bend to make a uniform flow of water. The inner diameter of the tube is 12mm and the outer diameter of the tube is 15mm.

The wire coil turbulator is made of circular steel wire with 1mm thickness or diameter. The wire coils of different spring pitch ratio 1cm were inserted into the tube by wall attachment position. The collectors with wire coil are kept in outdoor condition facing south direction with a tilting angle of 320 degree. The experiment is carried out for the entire day. The storage tank is completely drained in the evening after the experiment and is refilled with clean tap water in early morning. Thermometer is used to measure inlet, outlet, pipe and ambient tube temperature and is stored in the temperature recorder. Solar radiation is measured by pyranometer and pressure drop inside the tubes by differential pressure transducer.

Solar flat plate water heater consists of following components:

- Absorber plate
- Glazing
- Insulation
- Absorber tubes
- A wooden box or housing enclosing whole assembly.

Figure 2: Photographical View of Experimental Test Set Up

Performance Investigation

The first step before starting the experiments that had any inclusions of varying pitch turbulators was to measure plain tube readings keeping several parameters in mind to be calculated. The heat transfer coefficient, useful heat gain and final fluid temperature were such parameters which, sequentially thought to be measured under an available incoming solar radiation input. The comparison between twisted tape and coil-spring turbulator was calculated and the varying effect of these turbulator with respect to mass flow rate was examined. Figure 2 shows the variation in final temperature of the plain tube and the tube with different turbulator shapes. From the figure it can be seen that the high outlet fluid temperature is obtained using twisted tape turbulator followed by coil spring and the lowest is achieved using plain tube. This is mainly due to turbulence created inside the fluid flow as a result of turbulators in different shapes and forms. The twisted tape

turbulator are more efficient than coil-spring turbulator. Figure 3 shows the variation in heat transfer coefficient achieved at different mass flow rates pertaining to plain tube, coil spring turbulator and the twisted tube turbulator. It can be seen that the highest heat transfer coefficient is achieved in tube which contain twisted tape turbulators inside it followed by coil spring and plain tube.

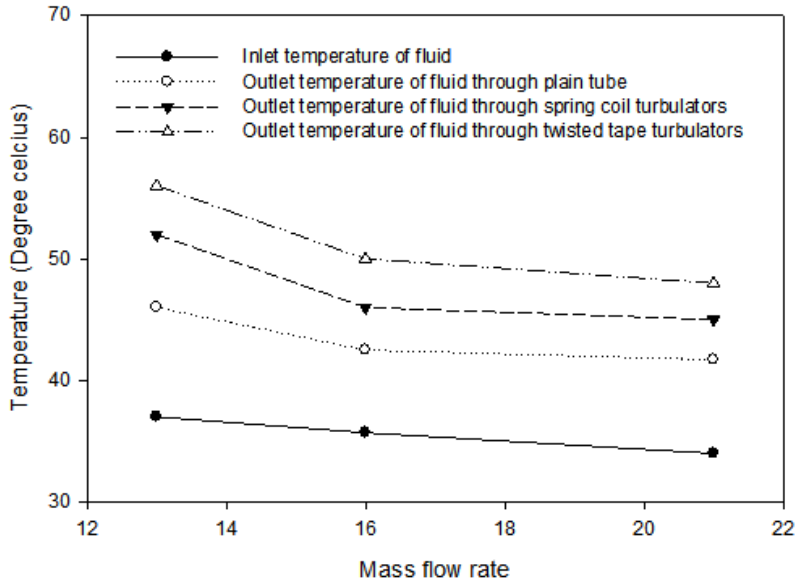

Figure 3: Variation of Final Temperature with Mass Flow Rate of Water

Also, the variation in useful heat gain with respect to the turbulators and plain tube is as shown in Figure 4. The highest heat gain is achieved with twisted tape turbulators compared to coil spring and plain tube because of higher turbulence level generated by twisted tapes. The maximum efficiency obtained from the twisted tape turbulators come out to be 63%.

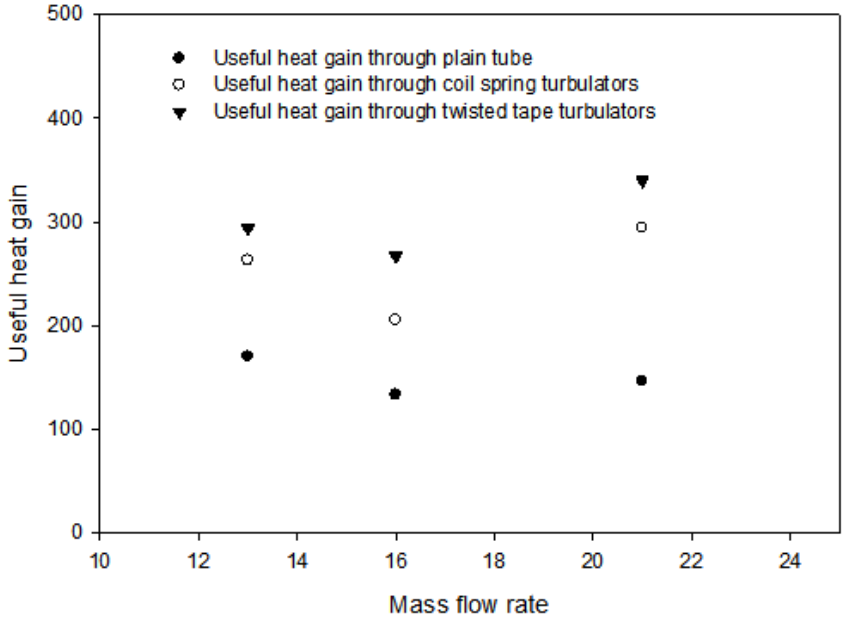

Figure 4: Comparison between Coil-Spring Turbulator and Twisted Tape Turbulator With Respect to Useful Heat Gain

CONCLUSIONS

The most significant concluding remarks obtained from the present study are:

- The highest outlet temperature, useful heat gain and the heat transfer coefficient are achieved using twisted tape turbulators as compared to coil spring turbulators.
- The higher value of each of the parameters investigated is as a result of higher value of turbulence generated compared to other turbulator shape investigated.
- The highest value of efficiency obtained from the investigated system is 63%.

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